

CC130 Hercules & CP140 Aurora Aircraft Anti-Icing Fluid (AAF) Flight Testing

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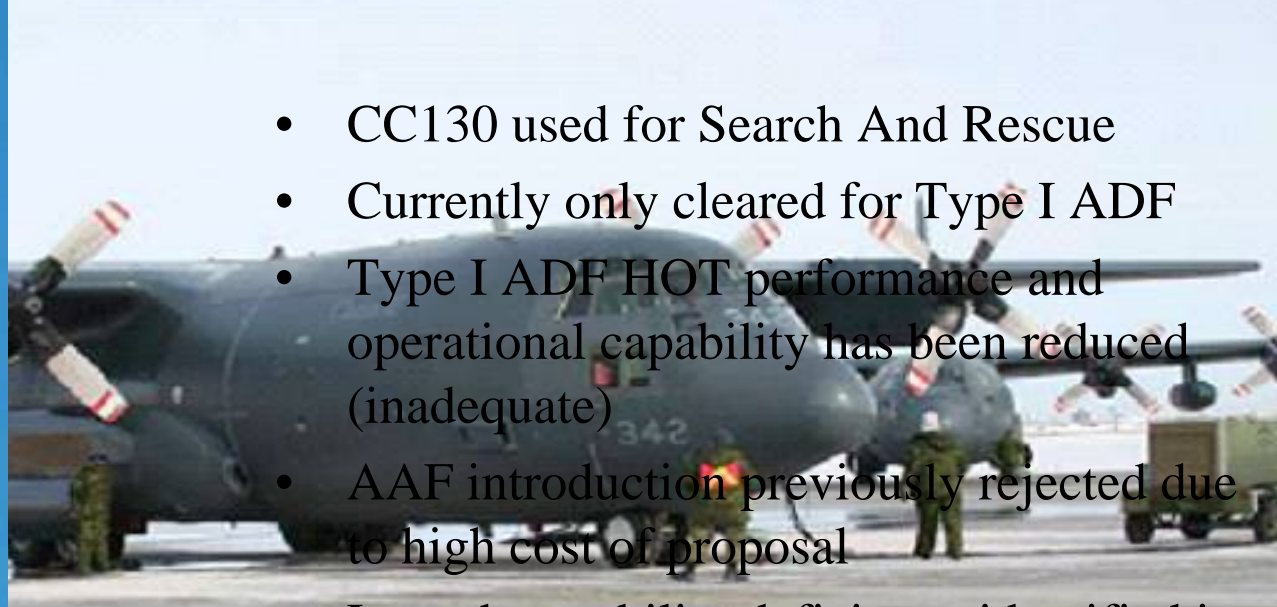
Department of National Defence (Canada)

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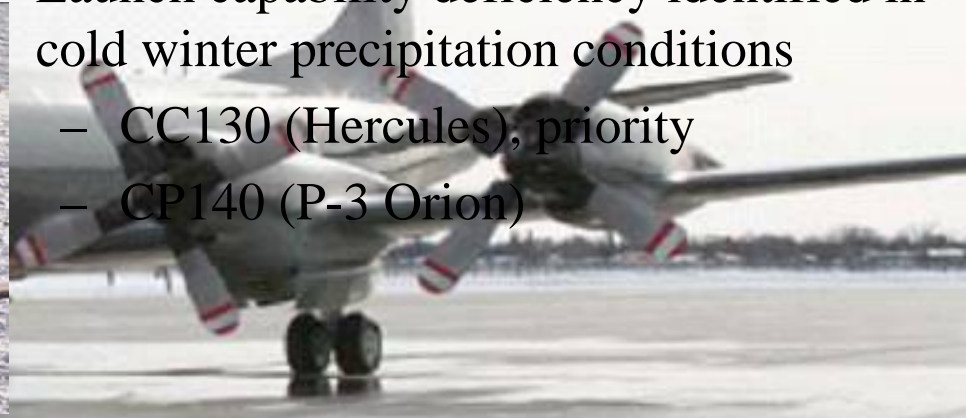
- Background
- Project Support Network
- Engineering Analysis
- Flight Testing
- Results
- Questions/Comments



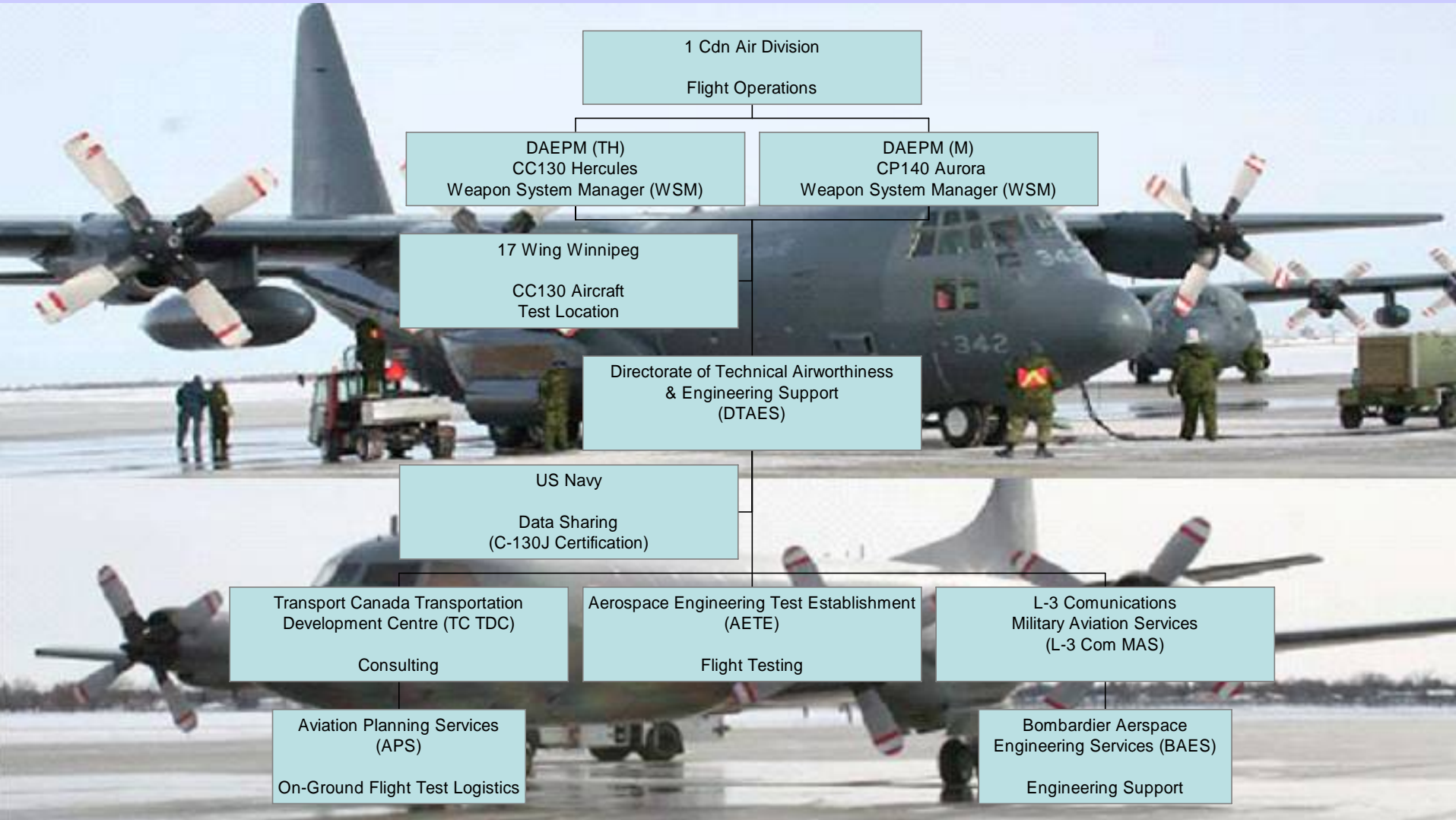
Background



- CC130 used for Search And Rescue
- Currently only cleared for Type I ADF
- Type I ADF HOT performance and operational capability has been reduced (inadequate)
- AAF introduction previously rejected due to high cost of proposal
- Launch capability deficiency identified in cold winter precipitation conditions
 - CC130 (Hercules), priority
 - CP140 (P-3 Orion)



Project Support Network



- **Bombardier Aerospace Engineering Services**

- Consulted due to their Dash 8 Experience
- Lower TO speeds and shorter ground roll
- Performed Dash 8 flight testing in Yellowknife, Canada
- Dash 8 cleared to use Type I, II, III, & IV fluid
- Speed penalties imposed on Dash 8 when using AAF





- The effect of De-icing and Anti-icing fluids on the aerodynamics of the DHC-8 aircraft was initially investigated in 1990 while de Havilland was a division of Boeing Commercial Aircraft
- Wind tunnel test was conducted in the Icing Research Wind Tunnel (IRT) at NASA Lewis (now Glenn Research Center) following a similar test by Boeing on a 737 model.



- The results of both sets of testing were used in the development of the SAE aerodynamic specifications for Type II, Type III and IV fluids
- 8% loss of maximum lift during take-off with anti-icing fluid has been widely accepted for propeller aircraft (~5.24% loss for jet a/c)
- Bombardier used their previous experience to evaluate the aerodynamics and flight systems of the CC130 and CP140
 - Recommended take-off speeds for flight testing with AAF
 - No change for CC130 recommended
 - 5 kt speed increase for the CP140 recommended



- **Bombardier Review**
 - Hercules Performance Charts (Change 4 – 15 May 2005)*
 - Aurora Performance Charts*
 - Hercules & Aurora Flight Control Systems
 - Power assist boosted system
 - New adjusted V_{LOF} are compared to the aircraft Take-off speed (greater of clean V_{LOF} or V_{MCA}).

- V_{LOF} = Lift-off Speed
- V_{MCA} = Minimum Control Speed - Air

***Calculations are based on latest OEM approved Performance Data for Canadian Forces (CF) Model Hercules and Aurora**

Flight Testing



- Canadian Forces (CF) performed the flight testing
 - Aerospace Engineering Test Establishment (AETE) in Cold Lake, Canada
- Winnipeg, Canada
- 28 Jan – 3 Feb 2007
- Flight test plan developed by AETE based on Bombardier's recommendations
- Required a temperature range between -16°C to -28°C with no precipitation
- Operational Aircraft (no instrumentation)



Flight Test Objectives



- Verify the handling characteristics of the CP140 and CC130 during take-off and shortly after take-off with AAF applied based on Bombardier's recommendations
 - 4 engine take-off
 - Simulated engine failure on take-off
- Handling Qualities & Pilot workload to maintain target attitudes in pitch and roll was assessed

Flight Testing Support



- Through Transport Canada Transportation Development Centre, APS was contracted for Flight Test support
 - Fluid thicknesses
 - Fluid sampling (Viscosity)
 - Skin Temperature
 - Fluid application
 - Air Canada
 - ATS
 - Glycol Recovery
 - Inland



- Type I fluid applied to wings, horizontal tail and vertical tail
 - 9538 Litres applied by Air Canada and ATS
- Type IV fluid applied to wings and horizontal tail
 - Total fluid sprayed: 4558 Litres
 - Kilfrost ABC-S
 - UCAR Dow Ultra+
- Flight testing was carried out as close to the LOUT as possible



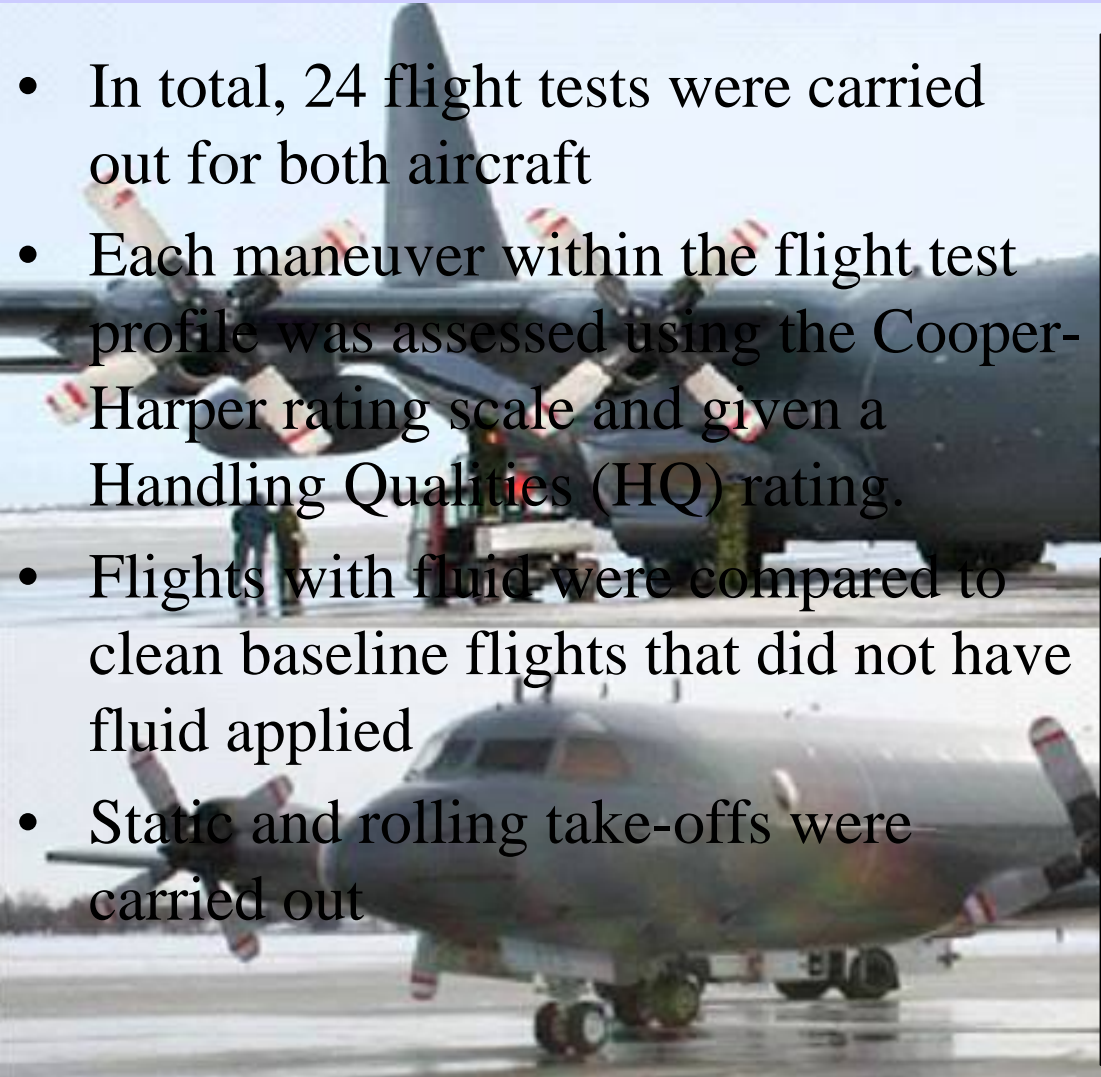
Flight Test Profiles



- Additional speed was used for earlier tests, and progressively reduced as the certification points were reached
- Each test flight was typically assessed using the following procedures:
 - 20° pitch capture
 - Once stable capture a pitch of 7° nose high
 - Once stable at 7° nose high, pitch as required to bank the aircraft to 30° left and right bank capture
- Above procedure carried out for 4-engine and simulated engine failure.



Flight Test Assessment



- In total, 24 flight tests were carried out for both aircraft
- Each maneuver within the flight test profile was assessed using the Cooper-Harper rating scale and given a Handling Qualities (HQ) rating.
- Flights with fluid were compared to clean baseline flights that did not have fluid applied
- Static and rolling take-offs were carried out

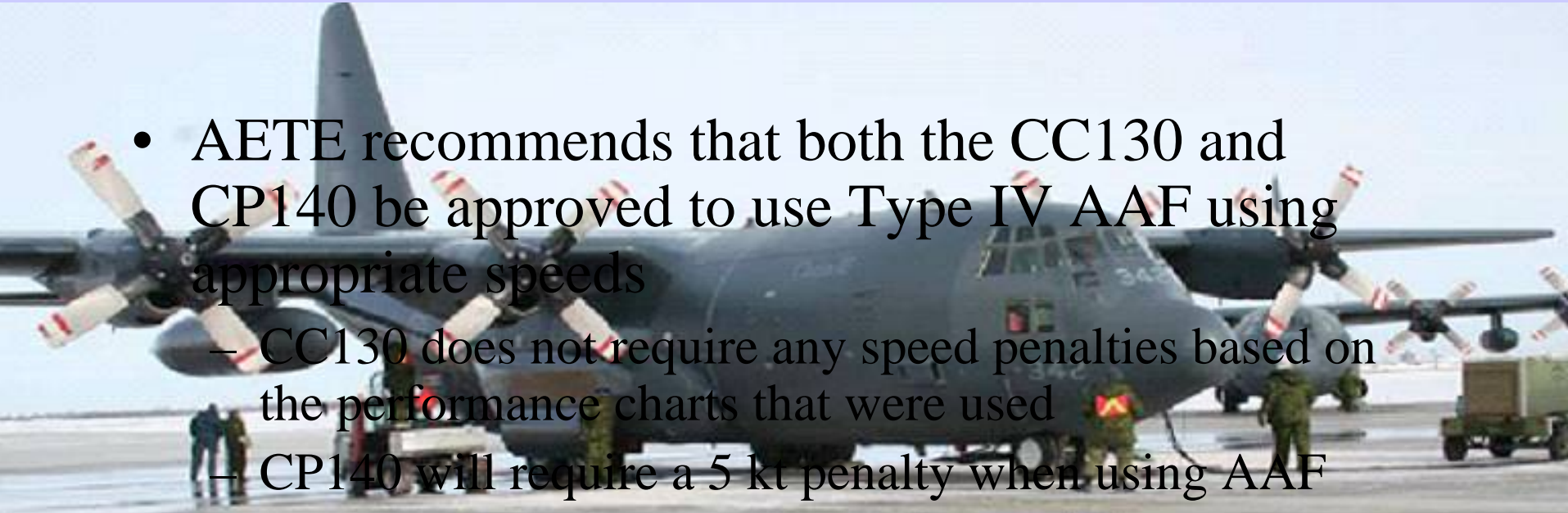
Flight Test Animation



Flight Test Animation




Results



- AETE recommends that both the CC130 and CP140 be approved to use Type IV AAF using appropriate speeds
 - CC130 does not require any speed penalties based on the performance charts that were used
 - CP140 will require a 5 kt penalty when using AAF



Note: These recommendations are only valid for:
CC130: C-12-130-000/MB-003 Change 4 – 15 May 2005
CP140: C-12-140-000/MB-001 Change 3 – 16 March 2003

- 
- Develop Flight Manual amendments for each fleet to use AAF – Nearly complete
 - Material compatibility testing/review
 - Completed
 - Review of maintenance procedures
 - Wash cycle
 - Wash procedures (aerodynamically quiet areas)

Certification & Anticipated Fleet Wide Usage



- Certification currently be carried out by DND
 - Technical Airworthiness Approval
 - Operational Airworthiness Approval
 - Approval to use SAE Type II, III and IV Aircraft Anti-icing fluids to individual fluid LOUT
- Planned fleet wide usage
 - 07/08 Winter season



QUESTIONS / COMMENTS

